Regional Analyses of Restoration Planning

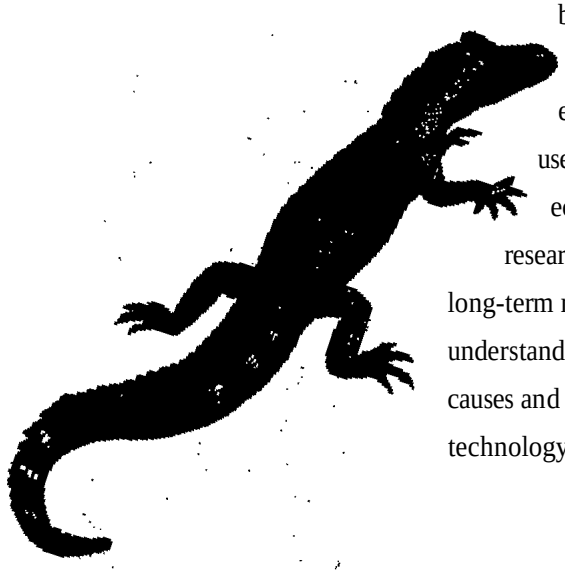
PART 4 – SOUTHEAST ATLANTIC

ESTUARIES OF THE SOUTHEAST ATLANTIC

The Southeast Atlantic region is defined here as the coastal and estuarine zones of the states of North Carolina, South Carolina, Georgia, the Atlantic coast of Florida (including South Florida, the Everglades, the Florida Keys and Florida Bay), the U.S. Virgin Islands and Puerto Rico.

The Southeast Atlantic region:

- Contains about 17.2 million acres of marsh and other estuarine habitat and 5.1 million acres of intertidal areas (http://caldera.sero.nmfs.gov/habitat/sp.htm).
- Includes the only emergent reefs off the continental U.S. (Causey et al., 2000).
- Contains the largest seagrass bed yet documented (5,791 square miles), which occurs off south Florida (www.fiu.edu/~seagrass/).
- Includes 3.9 million acres (18 percent of national total) of shellfish beds, ranking third in the total acreage of classified waters (NOAA, 1990).



SUMMARY

The Southeast Atlantic region is characterized by broad scale climatic patterns, which produce a diversity of ecosystems. In this region, restoration programs and plans are primarily implemented as regional or state level strategies. A review of restoration plans and programs determined that there is significant duplication of effort within and among federal and state initiatives. Several successful restoration methods were identified in this region. While mangrove restoration is still in need of further development, there are some examples of effective restoration methods that have been applied in the field such as the use of PVC pipes to stabilize mangrove propagules in order to protect them from washing away (this method is known as the Riley Encased Methodology). Another more recent technique being tested is the use of burlap, whereby four or five propagules may be placed on a section of burlap so that the roots of the propagules intertwine and protect one another from washout. Innovative approaches and new techniques also are being tested for coral and artificial reef enhancement. Until the 1980s, bundled automobile tires were most often used, but this practice was discontinued due to stability problems. Materials most often used include boating vessels, large diameter concrete pipe, train cars, bridge railing and rubble. A document entitled Guidelines for Marine Artificial Reef Materials, published by the Gulf States Marine Fisheries Commission, provides details and drawbacks of past uses of materials used for restoration and enhancement projects. Regional habitat restoration plans identify several research and information needs that are necessary to achieve long-term restoration success. Some of the information needs include understanding ecosystem structure and function; understanding the causes and effects of habitat alterations; and using the best available technology and methodology for effective habitat restoration.

INTRODUCTION

Description

For the purposes of this discussion, the Southeast Atlantic region includes North Carolina, South Carolina, Georgia, the Atlantic coast of Florida (including South Florida, the Florida Keys, the Everglades and Florida Bay), the U.S. Virgin Islands and Puerto Rico. The Southeast Atlantic estuarine region is one of the largest, most diverse and most productive coastal areas in the United States. Eighteen estuaries and two sub-estuaries, totaling almost 56,000 square miles of total drainage area, characterize the region. It represents the second highest U.S. region in wetlands and coral reef coverage area (NOAA, 1990).

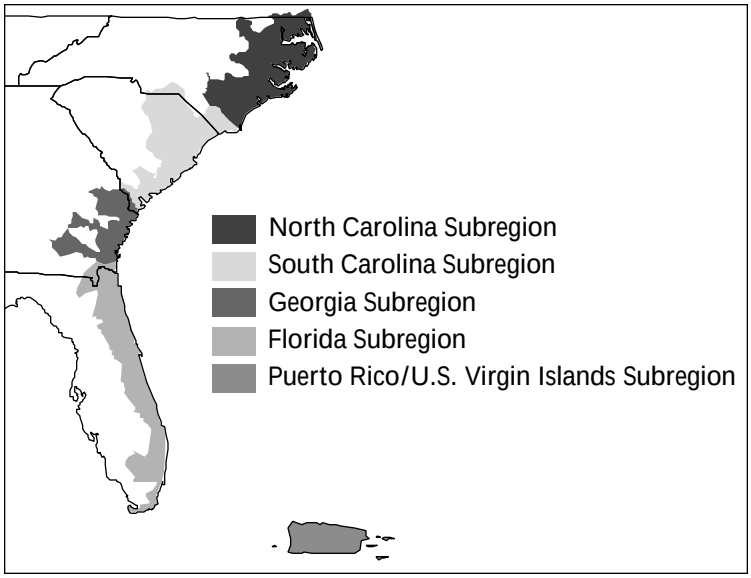


Figure 1: Southeast Region and Subregions

There is a great deal of diversity among land types and habitats within the Southeast region. River drainage areas range in size from 500 square miles (New River) to over 11,600 square miles (Albemarle-Pamlico Estuary) (NOAA, 1990). For the purposes of this discussion, the regional estuary systems are classified into three broad types: low-lying marshes within South Carolina and Georgia; lagoons and barrier islands along the coasts of North Carolina and Florida; and coral reefs and salt ponds within Puerto Rico and the U.S. Virgin Islands (White et al., 1995). Wetlands cover over 9,000 square miles of the region, and forested wetlands constitute three-quarters of southeast wetlands (NOAA, 1990). Total salt and brackish marsh acreage in this region is 894,000 acres, or 16 percent of the nation's total coastal wetlands (White et al., 1995).

Key Habitats and Species

Broad-scale climatic patterns explain much of this diversity, and the Southeast region's most distinctive characteristic is diversity at small scales. Due to these diverse environments and a long evolutionary isolation, a number of groups have reached continental high points of species richness in the Southeast Atlantic region, making it one of the most species-rich areas in the temperate zone, surpassed only by eastern Asia (White et al., 1995).

Historically, longleaf pine savanna was widely dominant on the Coastal Plain. Open habitats, including fens, bogs, glades, barrens and prairies; freshwater and saline marshes; sand dunes; and salt flats and rock outcrops, form island-like habitats within the matrix of closed forest. Over thirty plant and animal species associated with the longleaf pine habitat are listed as threatened or endangered, including red-cockaded woodpecker, fox squirrel and gopher tortoise (White et al., 1995).

It has been estimated that non-alluvial wetlands support more than one-third of the rare plants that occur in the Southeast Atlantic region and 23 species of rare, threatened or otherwise noteworthy plants have been identified in bays in South Carolina. Animals that depend on bay habitat include amphibians, the American alligator, freshwater turtles, snakes, and birds. Several animal species are endemic to particular bays; Lake Waccamaw, for example, supports at least two and possibly four endemic fish species, and three endemic mollusk species (White et al., 1995). Recreationally important fish species in the region include tarpon, American shad, and striped bass (Iliff, personal communication).

Pocosins are freshwater wetlands dominated by a dense cover of broad-leaved evergreen shrubs or low-growing trees with highly organic soils developed in areas of poor drainage. Several plant species depend on pocosin habitat, including whitewicky, arrowleaf shieldwort, spring-flowering goldenrod and roughleaf yellow loosestrife (White et al., 1995).

The coastal physiography of the northern and southern part of the South Atlantic Bight (North Carolina and Florida) is dominated by shallow water lagoons behind sand coastal barrier shorelines, while the central portion (South Carolina and Georgia) contains depositional marsh-filled lagoons. Estuarine marshes constitute a complex ecosystem that is vital to fish and wildlife including threatened and endangered species, furbearers and other mammals, waterfowl, wading birds, shore birds, reptiles and amphibians, shellfish and invertebrates.

Within this region, barrier islands and maritime forests are complex and dynamic ecosystems. Large numbers of migratory and nesting bird species are found on barrier islands. Coastal marshes are critical to overwintering populations of many

waterbirds. Southeastern barrier islands are included in the migration routes of many raptor species. Neotropical migrants use the islands as a resting stop when traveling to and from their winter habitats in the tropics. Nine endangered species of birds have been listed as wholly or partially dependent on southeastern barrier island habitats. These species use the barrier islands for nesting, migration, wintering, feeding, resting and roosting (Stalter and Odum, 1993).

Dunes and beaches provide essential nesting habitat for sea turtles. There are five species of sea turtles found in the open ocean and coastal waters of the Southeast Atlantic. All of these species nest on open beaches and include: the green sea turtle (endangered/threatened), the hawksbill (endangered), Kemp's ridley (endangered), the leatherback (endangered) and the loggerhead (threatened) (White et al., 1995).

In the Southeast Atlantic region, well-developed mangrove forests occur in South Florida, the U.S. Virgin Islands and Puerto Rico in areas where tidal waters produce saline conditions for all or part of the year. The red mangrove *(Rhizophora mangle),* black mangrove (*Avincennia germinans)* and white mangrove *(Laguncularia racemosa)* are the three true mangrove species found in the Southeast Atlantic. Mangrove habitats provide shelter for fish and invertebrates, contribute detritus to estuarine food webs, trap sediment and nutrients before they reach the sea, and protect coastal shorelines from the full effects of storms.

Seagrass beds in North Carolina and Florida are preferred habitat areas of many managed species such as shrimp, red drum, and estuarine-dependent snapper and grouper. In addition, many key species of birds (e.g., black brant), green turtles and manatees feed directly upon coastal and estuarine seagrasses (NOAA, 1998a; 1998b). Seagrass species found in the region include turtle grass (*Thalassia testudinum),* manatee grass *(Syringodium filiforme)* and shoal grass *(Halodule wrightii).*

The Southeast Atlantic region contains the only emergent coral reefs off the continental U.S. (Causey et al. 2000). Coral reefs help to build landmass in tropical environments, provide beach sand and offer protection to coastlines from hurricanes, storm erosion and flooding by reducing wave action. The number and density of species using coral reefs is extremely high and many reef taxa have yet to be described or inventoried (Bruckner, personal communication). Recent estimates of the extent of coral reefs in Puerto Rico by the Department of Natural and Environmental Resources have placed Puerto Rico's reef acreage second only to Hawaii's.

Florida Bay is a unique, relatively young subtropical lagoon with localized estuarine characteristics. Some scientists believe that the cumulative lack of freshwater inflow to Florida Bay, due to man-made water diversions coupled with other anthropogenic and possibly natural causes, led to a major seagrass die-off in the bay in 1987, followed by subsequent die-offs in the 1990s. The declining health of Florida Bay was a major catalyst for passage of the Comprehensive Everglades Restoration Plan, which in part proposes to restore freshwater inflow from the Everglades into Florida Bay (Porter and Porter 2001). The bay is inextricably linked to the Everglades and the Florida Keys reef tract. A decline in water quality associated with rapid population growth in the South Florida area and the subsequent increase in polluted runoff have a synergistic impact on the downstream coral reefs of the Florida Keys. Degraded water quality is a major concern for coastal managers in South Florida and the Florida Keys.

Oyster reefs and shell banks in the South Atlantic are composed of oyster shell, live oysters and other organisms that are discrete, contiguous and clearly distinguishable from scattered oysters in marshes and mudflats. The American oyster *(Crassostrea virginica)* extends over a wide latitude. The ecological role of the oyster reef is to provide structure, food and protection, and to filter impurities from the water column. This role is the reason intertidal oysters are described as "keystone" species, defined as species that are critical to a healthy coastal ecosystem (NOAA, 1998a; 1998b).

Oysters form living intertidal reef structures that support a host of other associated organisms including but not limited to birds, shellfish, mammals and invertebrates. Oysters also filter water by depositing suspended sediments on the estuarine bottom and removing excess nutrients. Improved water clarity has many benefits, one of which is allowing recolonization and growth of submerged aquatic vegetation. Oysters and their reefs buffer wave action, thereby reducing erosion to salt marshes and adjacent uplands.

Intertidal flats are diverse along the South Atlantic coast. Considerable regional variability in tidal ranges causes the diversity in distribution and character of the estimated one million acres of tidal flat habitat. The constantly changing systems provide nursery grounds for early development of benthic species, refuges and feeding grounds for forage species of fish, and feeding grounds for specialized predators (NOAA, 1998a; 1998b).

Free flowing riverine systems are the historic preferred habitat of anadromous fish populations. However, through the

damming of most significant riverine systems, the historic ranges of anadromous fish populations have been greatly reduced. Pollution and the construction of dams have resulted in substantial loss and degradation of suitable spawning habitat. South Atlantic coastal stream habitat from North Carolina to Florida is estimated to have been reduced by 77 percent due to the construction of 6,944 dams. The riverine habitat historically utilized by anadromous fishes has been reduced from approximately 152,862 miles of unobstructed stream access to 30,168 miles of optimal stream habitat (Busch et al., 1998). In addition, habitat alterations from discharges, dredging or disposal of material into rivers, and related development activities directly affecting riverine and estuarine mudflats and marshes, remain constant threats.

Mainstream spawning and juvenile rearing habitat for anadromous fishes has specific physical and biological characteristics for the successful reproduction and survival of anadromous fish populations. Streambed hydraulics and substrate composition are the primary factors for successful spawning of anadromous fish species. Optimal anadromous fish habitat is found in areas with cobble and gravel substrate and appropriate water velocities to maintain high levels of oxygenated waters for spawning and to prevent the excessive buildup of fine sediments throughout the incubation stage of larval anadromous species. Substantial groundwater upwelling contributes to specific spawning and essential temperature requirements.

Water level fluctuations within a riverine system can have an adverse effect on developing embryos depending upon the developmental stage and duration of the water level changes. The river flushing rate affects aquatic productivity, which is typically high in free-flowing sections of mainstream rivers. Submerged aquatic plant species allow for increased diversity of food sources, which includes macroinvertebrates and zooplankton, and provides protective cover for developing juvenile fishes. Organism diversity decreases in reservoirs created through the damming of free-flowing rivers. Thermal regime is another important habitat requirement that is altered through the stratification of dammed reservoir waters and releases of altered water temperatures downstream from permanent structures.

Southeast Atlantic anadromous fish management efforts should take a holistic ecosystem approach. Habitat restoration efforts within primary watersheds of the southeastern Atlantic should specifically address the cumulative impacts from habitat loss due to damming and expand present-day population ranges back to historic ranges. Habitat restoration measures include dam removal, breeching of dam structures, installation of fish ladders, or constructing natural dam bypasses to ensure that optimal habitat is available for future populations of anadromous fishes.

Anadromous fish species commonly found in southeastern Atlantic waters include American shad *(Alosa sapidissima)*, hickory shad *(Alosa mediocris)*, blueback herring *(Alosa aestivalis)*, alewife *(Alosa pseudoharengus)*, Atlantic sturgeon* *(Acipenser oxyrinchus)*, Shortnose sturgeon** *(Acipenser brevirostrum)*, and the striped bass *(Morone saxatilis)*. A catadromous fish species (one that spends its adult life in freshwater and spawns in the ocean) found in southeastern Atlantic waters is the American eel *(Anguilla rostrata)*.

**The Atlantic sturgeon is a candidate species of federal concern.*
***The Shortnose sturgeon was federally listed as endangered in 1967 and is still endangered today.*

Habitat-Dependent Activities

Traditionally, forests have been the dominant land cover within the estuarine and coastal regimes of the southeastern U.S., accounting for about 33 percent of all land within the estuarine drainage areas. Agriculture accounts for 22 percent of the lands within estuarine drainage areas. Winyah Bay, Ossabaw Sound, Broad River and Indian River each have over 30 percent of their lands classified as agricultural (NOAA, 1990).

Although urban centers represent only about four percent of its estuarine drainage areas, Florida has a rapidly urbanizing coast extending north from Miami to Jacksonville at the mouth of the St. Johns River. The population in 126 counties of this region is projected to increase by more than 24 percent between 1988 and 2010 (NOAA, 1990). The southeastern U.S. coastal region continues to attract visitors and residents in increasing numbers, with consequent stress to and loss of the natural resources and habitats within these coastal and estuarine zones.

There are nearly 2,700 public outdoor recreation sites comprising about 5,200 square miles of land in this coastal region. Over 60 percent of these lands are managed for hunting, while about 32 percent are set aside for conservation, preservation and aesthetic value. Of the almost 900 public sites which provide access to the water, 61 percent are adjacent to estuarine waters and 36 percent provide access to the Atlantic Ocean. Florida has the largest concentration of private sites in the region (70 percent of the region's total) (NOAA, 1990).

Coral reefs are the major marine tourist attraction in the southeast. In the Florida Keys alone, coral reefs are credited with

generating $1.2 billion in tourism revenue each year from four million visitors (English et al., 1996). Economically and culturally important fisheries of the U.S. Virgin Islands and Puerto Rico (specifically reef fish, conch, lobster and aquarium species in trade) are completely dependent on reef habitats (Bruckner, personal communication).

Habitat Status and Trends

Based on an analysis of plans within the Southeast region, findings indicate that the major factors contributing to estuarine and coastal habitat loss and degradation include: logging, conversion to agriculture and development, hydrological alteration, and anthropogenic and natural threats. Table 1 summarizes some of the key past, present and future threats for all subregions of the Southeast.

Within private or public land, pristine areas and rare habitats in the Southeast Atlantic region have suffered significant losses, and human effects have permeated the region, rather than encroaching into the region along one or even several fronts (White et al., 1995).

Data from 1987 show that although 55 percent of the southeast region's land was forested, there was a downward trend and a decline of five percent since 1960 (U.S. Forest Service, 1988; Martin and Boyce, 1993). The rest of the land was used for crop and pasture (31 percent) and miscellaneous purposes (roads, towns, cities, airports: 14 percent). Urban areas were growing at the fastest rate (White et al., 1995).

Predictions of trends in land use include a decline in forest land by 15 percent over the next 50 years (with additional forest land converted from natural to plantation forests); a slight decline in agricultural land (with a continued shift from small to large farming operations); and an increase in urban areas. These predictions suggest that further habitat loss and fragmentation will occur near human population centers (Boyce and Martin, 1993).

In Georgia, the Savannah River has experienced the greatest human impact. Large dams, dredging and channelization have removed the vegetated flood plains in the freshwater tidal zone. It has been estimated that 78 percent of southeastern wetlands were lost between settlement and 1980 (Noss et al., 1995). Southern floodplain forests may constitute the largest remaining riparian habitat type in the United States. Estimates of extent vary from 25,482 square miles to 50,193 square miles. This areal extent is decreasing (0.51 percent per year from 1954 to 1974), with a total loss of about 63 percent. These forests have been converted to farmland, industrial parks and urban areas while levee construction, channelization, agricultural runoff, cattle grazing, timber extraction and invasions of non-indigenous species influence surviving stands (White et al., 1995).

Within the Southeast region, human activities have had a major effect on barrier island habitats over the past 50 years. Development has meant the construction of jetties and sea walls, filling and draining of marshes, and extensive dune stabilization and beach nourishment programs, all of which obstruct the natural fluctuations of the barrier island communities. Although there remain isolated stretches of protected barrier island beaches and dunes and intact salt- and freshwater marshes, nearly half of the area of these communities is estimated to have been lost (White et al., 1995).

Many birds have been negatively affected by development and human encroachment. Species that nest in bare sand can be disturbed by pedestrian and off-road vehicle traffic, and by the construction of artificial dunes. Loss of habitat due to coastal development also can have a detrimental effect on seabird and shorebird populations that may use mangroves, coastal and riparian forests, or dune vegetation to nest and roost.

Historically, the Florida Everglades system extended from Lake Okeechobee to Florida Bay. However, 50 percent of the original wetland area (3,861 square miles) has been drained and used for agriculture and development. The remaining area lies within impoundments of the South Florida Water Management District (White et al., 1995).

An exemplary study of landscape change in the historical Everglades (Davis et al, 1994) showed three of seven physiographic landscapes had been entirely eliminated (swamp or custard-apple forest, peripheral wet prairie, and bald cypress stand), and other landscape types had been reduced by 74 percent (sawgrass plains), 47 percent (sawgrass-dominated mosaic), 24 percent (southern marl-forming marshes) and 13 percent (wet prairie/slough-tree island-sawgrass mosaic). On the local scale, wet prairie and slough decreased by 25 percent, and sawgrass marsh increased by 33 percent, a change attributed to lower water levels. The study concluded that the factors responsible for the historical configuration of habitats were extended hydroperiods and slow water flow caused by the presence of extensive sawgrass marshes, punctuated by drought years with severe fires. However, due to man-made alterations in the natural hydrological flow, historic estuaries such as Florida Bay have been starved of freshwater, resulting in significant shifts in the natural ecosystem and subsequent seagrass die-offs.

TABLE 1. KEY THREATS IN THE SOUTHEAST ATLANTIC REGION

Threats	Description	Subregions
Agriculture	Conversion of wetlands to agricultural lands; direct and indirect nonpoint source discharges of fill, nutrients and chemicals; hydrologic modifications to create ditches, dikes and farm ponds; damage to wetlands and submerged lands by livestock; and cumulative and synergistic effects of these impacts.	N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.*
Aquaculture	Dredging and filling of wetlands and other coastal habitats through the introduction of pens; nets and other containment devices; and introduction of waste products and toxic chemicals.	N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Silviculture	Conversion of wetlands to production sites with related impacts similar to those listed for agriculture.	N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Urban, suburban and coastal development	Conversion of wetlands and coastal habitats to sites for residential or commercial uses with some of the following associated impacts: direct and indirect nonpoint source discharges of fill, nutrients and chemicals; hydrologic modifications; damage to coastal dunes, wetlands and other sensitive habitats; and cumulative and synergistic effects caused by these impacts.	N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Industrial and commercial activities	Impacts similar to those listed for agriculture and urban and suburban development.	N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Navigation	Port construction and operation; channel dredging and stabilization projects; discharge of fuels or other chemicals; turbidity; ship groundings/prop damage/sinking in sensitive areas; and transfer of exotic species through ballast water discharge.	N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Land subsidence and erosion		N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Vessel operation	Impacts similar to those listed for navigation and gear-related impacts such as damage to coral reefs caused by the improper setting of anchors; mono-filament line and ghost nets (threatens marine and coastal species); propeller scarring (causes irreparable damage to seagrass habitat); and shrimp trawling (damages important benthic habitats).	N.C.**, S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Inshore mining	Phosphate and marl mining.	N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Hydrologic modifications	Mosquito control, agriculture, flood control projects, urban and suburban development, deprivation of freshwater from upland watersheds and saltwater intrusion.	N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Dams, impoundments, barriers to fish passage		N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Point and nonpoint source pollution	Pollutants, including chemical, sediment, stormwater source runoff, nutrients and bacteria.	N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Natural events	Coastal storms, hurricanes, global warming and sea level rise.***	N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Dumping	Burial of habitats with fill or debris; introduction of toxics and contaminants; and associated turbidity.	N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Illegal cutting or removal of key species		N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.
Adverse impacts associated with over-harvesting of resources		N.C., S.C., Fla., Ga., Puerto Rico and U.S.V.I.

**For Puerto Rico and the U.S. Virgin Islands, agricultural threats also include impacts associated with cattle grazing, such as degradation of wetlands and deforestation.*

***For N.C., vessel operation threats include impacts similar to those listed for navigation and gear-related impacts with the addition of impacts associated with damage from clam kicking and clam dredging.*

****Note that global warming and sea level rise are topics of extensive scientific debate regarding whether these phenomena are caused by natural climatic fluctuations, anthropogenic factors, or whether it may be a combination of the two.*

In addition to historic freshwater flow alterations, the Everglades are facing a number of threats: nonindigenous plant invasions and sea-level rise (sea level rise is occurring at a rate 6 to 10 times higher than in the past 3,200 years, possibly affected by global warming (Light and Dineen, 1994). Light and Dineen (1994) reviewed the role of agriculture in causing peat subsidence through increased oxidation of organic matter and suggested that the late 1900s may well have been the high point of agricultural production in the area because of the eventual loss of peat soils.

Upland outcroppings of limestone in south Florida support pine rockland and tropical hardwood hammocks that are unique in the continental United States (Snyder et al., 1990). The extent of these ecosystems has been greatly reduced by development and conversion to agriculture. Although wetlands have decreased by 40 percent to 50 percent since 1900, the more restricted upland pine forests have decreased by 80 percent (Robertson and Frederick, 1994). Most of the remaining stands of pine rockland and tropical hardwood hammocks in peninsular Florida are protected in Everglades National Park or by state or local governments. In contrast, most of the remaining undeveloped land in the Florida Keys is privately owned and likely to be developed, with the exception of that in the lower Keys lying within national wildlife refuges. Even where upland vegetation is protected, species survival is not guaranteed. Fire is essential to the management of pine rockland vegetation, and pine and tropical hardwood hammocks are severely threatened by invasions of nonindigenous animal and plant species (Snyder et al., 1990).

There are about 780 square miles of mangrove forests in Florida (Gilmore and Snedaker, 1993). Odum and McIvor (1990) reviewed data that indicated a loss of about 2.5 percent of the mangrove habitat between 1943 and 1970 in the three counties with the highest original total. Overall areal extent of this habitat has been reduced by coastal development (draining and filling for urban areas and mosquito control); reductions in freshwater flow because of diversion of runoff from inland areas; invasion of nonindigenous species; port development; and natural causes such as tropical storms and hurricanes.

There were nine square miles of mangrove in the U.S. Virgin Islands and Puerto Rico in 1995, an increase of 61.2 percent since 1936. Marsh areas in 1995 were three square miles, a decrease of 42.2 percent since 1936. Combined, there was a gain of 1.5 square miles or about 20.6 percent. The apparent gain of mangrove forest could be the result of a successional change from one type of habitat to another due to natural and/or human influences. By 1936, significant impacts to the wetlands of the area had occurred due to sugar cane plantations. The increase in wetland area corresponds to the natural regeneration process following abandonment of agricultural activities.

Coral reefs in the Southeast Atlantic region are subjected to greater stress than anywhere else in the United States. Human impacts tend to be significant because of large, concentrated coastal populations located in sensitive areas. Land runoff and coastal pollution problems introduce sediments, pesticides, sewage, fertilizers and heavy metals into coral habitats, particularly where large populations are centered close to reefs. Vessel groundings, anchor damage and tourism impacts are more prevalent throughout the southeastern U.S. and the Caribbean islands because of high levels of recreational activity by residents and visitors (Bruckner, personal communication).

Regional Planning Efforts

Within the region, some programs and plans encourage a regional approach to restoration planning. Some examples are described below. A list of plans can be found in the National Strategy Restoration Plan Database (http://restoration.nos.noaa.gov).

Habitat Plan for the South Atlantic Region: Essential Fish Habitat Requirements for Fishery Management Plans of the South Atlantic Fishery Management Council

In order to address the new essential fish habitats mandates in the Magnuson-Stevens Act, the South Atlantic Fisheries Management Council began development of a habitat plan that will serve as a source document describing essential fish habitat; a comprehensive amendment to each of the existing fishery management plans; and a monitoring program for each fishery management plan to determine new impacts from fishing gear and practices that will have an adverse affect on essential fish habitat. The description of essential fish habitat in the Habitat Plan includes estuarine inshore habitats, mainly focusing on North Carolina, South Carolina, Georgia and Florida (east coast), as well as adjacent offshore marine habitats (coral reefs, coral, live and hard bottom habitat, artificial reefs, Sargassum habitat and the water column).

Partners In Flight

Partners In Flight (PIF) is a consortium of public and private organizations and individuals working to conserve land birds throughout the Western Hemisphere. PIF's guiding principles are to restore populations of the most imperiled species and to prevent other birds from becoming endangered. A comprehensive set of regional Bird Conservation Plans for land birds in the continental U.S. was completed by the PIF partnerships in

2000. Bird Conservation plans which cover the southeast include the South Atlantic Coastal Plain Plan; the Peninsular Florida Plan; and the Subtropical Florida Plan.

North American Waterfowl Management Plan

In 1986, the United States and Canada signed the North American Waterfowl Management Plan (joined by Mexico in 1994). This international agreement challenged conservationists in North America to restore waterfowl populations to 1970s levels. Most importantly, it directed that this be accomplished by creating sustainable landscapes for waterfowl using unprecedented partnerships among the federal, state and private sectors. This constituency facilitated the passage of the 1989 North American Wetlands Conservation Act, the primary funding tool for habitat conservation under the plan. Within the Southeast Atlantic region, the Atlantic Coast Joint Venture includes the states of Delaware, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia and Florida.

Plan Elements

Goals

The review of restoration plans identified similar goals among restoration efforts. These goals include: formation of partnerships and cooperative efforts; development of (or identification of the need for a strong scientific basis for restoration efforts; setting priorities within the geographic zone or range; defining the appropriate geographic scale for given restoration goals; planning with an ecological approach; and developing a clear understanding of the possible causes and effects of habitat loss and degradation.

Methods

Several restoration plans with a regional focus provide some information on methods that have been used or recommended for achieving the region's restoration goals. The methods are categorized by key habitats and briefly outlined below:

1. **Estuary intertidal.** Restoration or creation most often involves designing the project site with appropriate hydrology, tidal exchange and sediment properties to support continued growth of marsh species. Physical modification of a site is followed by planting, most often Spartina alterniflora or Spartina patens. Restoration of intertidal marsh also is accomplished by removal of the impediment to tidal exchange (e.g., removal of shoreline hardening structures such as bulkheads, dikes or fill).

2. **Mangrove ecosystems.** Mangrove habitat restoration techniques have evolved over time. Shortfalls in early restoration attempts have been identified and can be avoided by proper restoration planning. The single most important factor in designing a successful mangrove restoration project is determining the hydrology (frequency and duration of tidal flooding) typical of existing mangrove plant communities near the restoration site (Lewis and Streever, 2000). Although mangrove restoration techniques still require further development, there are some examples of effective restoration methods that have been applied in the field. One method involves the use of PVC pipes to stabilize mangrove propagules and protect them from washing away (this is known as the Riley Encased Methodology). Another more recent technique that is being tested is the use of burlap, whereby four or five propagules may be placed on a section of burlap so that the roots of the propagules intertwine and protect one another from washing out.

3. **Seagrass (submerged aquatic vegetation).** Most effective techniques involve transplantation of species (e.g., from nursery-grown shoots or existing seagrass beds). Most effective restoration occurs within protected coastal lagoons, behind protection of barrier islands. An innovative approach to seagrass restoration in South Florida entails the use of temporary bird-roosting stakes for fertilizer-enhanced seagrass recolonization (http://shrimp.bea.nmfs.gov/~mfonseca/lvfinalreport.pdf – report by Kenworthy et al.). Restoration of propeller scars and "blowholes" from vessel groundings are accomplished by replacing lost sediment coupled with seagrass transplanting. Efforts are increasing to protect seagrass habitats by proactive management (avoid impacts and/or losses). Research continues to evaluate current techniques and develop new approaches (e.g., clonal development).

4. **Oyster reefs and shellbanks.** Restoration efforts most often involve the eastern oyster, Crassostrea virginica. Restoration or enhancement involves both the distribution of clean shell material as settlement substrate for juvenile shellfish larvae and "seeding" with sub-adult stage oysters. If oysters are naturally occurring in an area, oyster spat will colonize cultched area; however more intensive restoration of all life phases of oysters may be needed in areas devoid of active oyster population. Widespread presence of pathogens such as Dermo and MSX may present problems with transplantation of oysters.

5. **Tidal flats.** While tidal flats have some legal protection as vegetated intertidal areas, permits have been relatively easy to obtain for dredging and/or filling of these habitats. Restoration involves removal of fill (if filled) or restoration

of appropriate grades by filling (if dredged).

6. **Coral, man-made reefs and live/hard bottom.** Most restoration efforts focus on artificial reef enhancement or construction. North Carolina, South Carolina, Georgia and Florida have or are developing artificial reef management plans. Until the 1980s, bundled automobile tires were most often used, but this practice was discontinued due to stability problems. Materials most often used to construct artificial reefs include boating vessels, large diameter concrete pipe, train cars, bridge railing and rubble. Guidelines for Marine Artificial Reef Materials, published by the Gulf States Marine Fisheries Commission, provides details on experiences and drawbacks of past uses of materials used for restoration and enhancement projects. Habitat enhancement through the construction of man-made reefs can be achieved by conversion of mud, sand, shell or other soft bottom habitats into hard bottom communities by the addition of hard structure with low or high relief.

   Coral reef restoration projects also focus on repairing corals damaged by ship groundings. An example is the NOAA Fisheries Mona Island coral reef restoration project in Puerto Rico. After a merchant vessel known as the M/V Fortuna Reefer ran aground on a shallow-water fringing reef dominated by elkhorn coral (*Acropora palmata*) off Mona Island, scientists used an innovative method of reattaching and stabilizing broken pieces of coral. Loose branches of coral were secured to the reef buttress and to existent relic Acropora framework using stainless steel wire and nails, permitting timely removal of injured coral from sand areas where they were being smothered. It also minimized abrasion damage to broken coral pieces from swell and wave motion. A number of stabilization techniques were tested, and it was determined that the best method consisted of drilling holes into the reef, driving nails into the holes, and wiring corals to the reef. At the conclusion of the restoration effort, 1,857 coral fragments had been stabilized, and monitoring stations to track the success of the restoration effort had been established.

7. **Anadromous fish passage corridors.** Most common techniques involve the removal of a dam (e.g., Quaker Neck Dam in North Carolina) or other obstruction to fish migration. Other methods include the installation of fish passage structures (dam notches, fish ladders, elevators, baffles, appropriately-sized culverts, step pools) to facilitate fish passage where obstructions cannot be removed. Restoration of formal hydrologic conditions may be accompanied by active stream or shoreline restoration which includes replanting and/or reestablishment of natural in-stream morphology.
8. **Beach and dune ecosystems.** Restoration of beaches most often involves placement of sand or nourishment by various methods, such as offshore dredging and disposal with hopper or mechanical dredges, or hauling of material to site and spreading by bulldozer. The use of bulldozers to redistribute sand in post-storm periods is a very common practice in the hurricane-prone southeast region. Beach bulldozing, or "scraping," most often is designed to move overwash materials back onto a beach or to move sand eroded into the intertidal zone during a storm to re-establish a dune line. Dune planting most often accompanies beach scraping, and involves planting dune flora such as Ammophila breviligulata and/or Uniola paniculata. The practices of beach nourishment and beach scraping are not universally accepted as viable habitat restoration practices. It is generally agreed that new technologies need to be explored. The benefits versus the adverse impacts to beach and dune species as a result of beach nourishment is currently a topic of research and debate within this region.

9. **Bird corridor and ecosystems restoration.** Restoration efforts included within the various conservation plans and programs (outlined under the North American Bird Conservation Initiative in the U.S.) involve a suite of restoration methods and options including both habitat preservation principles (through purchase of lands or conservation easements) and active restoration techniques designed to restore and/or enhance bird habitats (e.g., improving impoundment construction and management, establishing forested "greenways" or planting riparian buffers, removal of impediments to habitat access such as shoreline hardening structures, or contaminants.).

Elements of Success

Of the documents reviewed with a regional planning focus, most efforts emphasize the need for partnerships, education and outreach efforts (depicting the benefits derived and importance of habitat restoration), and having adequate and sustained funding for restoration efforts that go beyond a project-level approach. The use of best available technology, both for the planning and implementation phases of restoration efforts, was mentioned as key to successful efforts. Plans also emphasized the need for incorporation of restoration into larger, watershed or basin level efforts, together with meaningful prioritization of key habitats and species, and well-defined pre- and post-construction monitoring, to guide needed research and adaptive management efforts.

Information Needs

Regional habitat restoration plans cite the following information needs as significant to achieving long-term restoration goals:

- **Ecosystem structure and function:** More research is needed to understand the structure and function of natural ecosystems, their linkages to one another, and the role they play in supporting and sustaining living resources, their abundance, distribution and health. Knowing when and how systems are affected, assessing the cause and degree of impact, and providing the basis for restoring and maintaining these systems are integral to this research area.

- **Effects of habitat alterations:** Quantification of the causes of damage to ecosystems is critical to restoration and prevention of future losses. There also is a need to quantify the response of habitats and living resources to natural and anthropogenic alterations.

- **Habitat restoration methods:** Many methods for restoration have not been rigorously tested under experimental conditions throughout wide geographic ranges and at different scales (e.g., salt marsh restoration). For other habitats (e.g., coral reefs, riparian habitat, intertidal substrates) only limited methodology exists; little emphasis has been placed on rapidly restoring biodiversity and monitoring for success and persistence. Research areas and areas of concern include analyses of the successes of contaminant sequestration, assessment of bioremediation techniques, development and evaluation of new restoration techniques, experiments on transplant species culture techniques, and evaluation of the role and size of buffers and the importance of habitat heterogeneity in the restoration process.

- **Indicators of habitat and living resources impacts and recovery:** There is a need to develop indicators to determine whether an ecosystem, habitat or living resource is healthy, degraded or recovering. The development of indicators must be based on information derived from comparative research on the structure and function of disturbed, natural and/or restored habitats of different ages and geographical locations for a suite of biological, chemical and physical parameters; time-dependent biotic populations analyses; and contaminant level follow-up evaluations for sediment, biota and water.

- **Synthesis and information transfer:** Synthesis and timely transfer of information derived from research findings and the existing literature is a key element of the essential fish habitat research and monitoring program. Decisions on permitting, regulations, enforcement, redirection of research efforts and development and implementation of restoration plans must be made with best available data.

- **Implementation:** The elements listed above must be interlinked to provide a framework for effective research and management. Research on ecosystem structure and function must be known in order to effectively determine the effects of habitat alteration, develop restoration methods and develop indicators of impact and/or recovery.

- **Better science and information:** In order to maximize the biological diversity that exists in the southeast, a better understanding of the following issues is required.
  - Sensitivity of species to habitat fragmentation and the persistence of species in agricultural landscapes of various types.
  - Roles of hydrological regimes and fires of various intensities and in different seasons.
  - Ways to avoid future nonindigenous species problems and to control the problems that already exist.
  - Sustainable methods and levels of harvest, both for target species and for non-target species that are affected by harvest.
  - Ways to propagate species taken directly from the wild to avoid damage to surviving natural areas.
  - Ways to develop off-site gene and species banks as last resorts for the rarest and most threatened species.
  - Ways to restore natural processes and whole systems on the ubiquitous degraded lands in the southeast.
  - Ways to predict the varying sensitivities of ecosystems and species to sea level rise and climatic change.

Southeastern Atlantic Subregions

From a primarily ecological standpoint, the Southeast region can be divided into several bioregions: the South Atlantic coastal plain, Peninsular Florida, Atlantic Coastal Florida and the U.S. Virgin Islands and Puerto Rico.

Although these areas may be grouped by biological and geological similarities, *A National Strategy* adopts state-by-state subregions to identify and characterize the estuarine drainage areas and coastal subregions in the Southeast Atlantic region. The analysis of the region's status and trends, threats, and ongoing restoration efforts are best understood within a state-by-state framework.

The following sections summarize the habitat issues and highlight certain restoration planning efforts for each of the South-

east Atlantic subregions. Detailed information and additional plans are available in the National Strategy Restoration Plan Database (http://restoration.nos.noaa.gov).

North Carolina Subregion

Description

North Carolina encompasses 2.2 million acres of sounds, creeks and marshes, and nearly 4,400 miles of estuarine shoreline. The state includes eight coastal river basins, which provide spawning habitat for a number of anadromous species of fish. Approximately 50 percent of the fish caught on the east coast of the United States depend upon North Carolina's estuarine system at some point in their life cycles. Of the nearly five million acres of wetlands located in North Carolina, over 95 percent are found in the 41 counties that make up the Coastal Plain (Holman and Childres, 1995).

Within North Carolina, the Albemarle-Pamlico Estuary (APES) is a huge complex of shallow sounds, rivers and wetlands. With a total water area that exceeds 2,900 square miles, it is the second largest estuary system in the country. APES is composed of seven sounds (Albemarle, Currituck, Croatan, Pamlico, Bogue, Core and Roanoke) and is drained by several major river basins. The entire APES region consists of 1.8 million acres of brackish estuarine waters (Albermarle-Pamlico Estuarine Study, 1990).

The sounds of North Carolina are uniquely characterized by wind-driven tides that affect circulation patterns within the sounds and saltwater concentrations in their tributaries.

Habitat Issues

Status and Trends

Within North Carolina estuaries, fish landings, seagrass beds and catches of clams, oysters and bay scallops have all experienced declining trends due in part to overfishing, eutrophication, sediment loadings and other pollution. Throughout North Carolina, the areas closed to shellfishing as a result of long-term pollutant monitoring increased by nearly 40,000 acres over a thirteen-year period (NCDENR, 1999). This increase can be attributed to increased nonpoint source pollution loads in rapidly growing regions. Pressure on sensitive ecosystems has resulted from increased coastal development. Currituck, Dare, Hyde, Carteret, Onslow, Pender, New Hanover and Brunswick counties experienced a population increase of 32 percent between 1977 and 1997.

Threats

Key threats for this subregion are listed in Table 1. Urbanization and population growth have led to greatly increased nonpoint source pollution of coastal waters. Point source discharges are increasing as well. In the Cape Fear Basin alone, there are 641 licensed point source discharges (NCDENR, 1999). Eighteen of North Carolina's 26 commercially important fish species are exhibiting signs of stress from overfishing or environmental degradation (Center for Watershed Protection and Land Ethics, Inc., undated).

Within North Carolina, pollution from stormwater and marinas has resulted in the permanent closure of 56,000 acres of shellfish waters. Since 1990 more than 1,000 acres of Outstanding Resource Waters, so designated because of their superior quality, have been closed to shellfishing. State reporting indicates that nonpoint source pollution is thought to account for 85 percent of the total impaired acreage (NCDENR, 1999).

Restoration Plans

Albemarle-Pamlico Comprehensive Conservation Management Plan (CCMP)

As part of the National Estuary Program, the Albemarle-Pamlico Estuary (APES) was identified as a significant estuary threatened by pollution and development. The Albemarle-Pamlico CCMP is a comprehensive plan for conservation and management of the estuary. The plan promotes regional planning to protect and restore the natural heritage of the APES region. It has been partially implemented through the development of new programs and eight coastal basin-wide plans.

North Carolina Wetlands Restoration Program (NCWRP) and Associated Plans

The NCWRP was created as a nonregulatory program for the acquisition, maintenance, restoration, enhancement and creation of wetland and riparian resources. Its purpose is to restore degraded wetlands and riparian areas throughout all of North Carolina's river basins to compensate for the loss of vital functions and values that have occurred through wetlands conversion. The NCWRP developed restoration plans for all eight coastal river basins in North Carolina, and is pursuing restoration projects in accordance with those plans.

North Carolina Estuarine Research Reserve Management Plan

The North Carolina Estuarine Research Reserve was established in 1985 and currently encompasses 10,000 acres of protected estuarine lands and waters. The reserve management plan was approved by NOAA in 1998. Important habitats at

the four reserve components that may be useful for investigation and as reference sites include maritime forests, shrub thickets, freshwater, brackish, and saltwater marshes; mud and salt flats, sandy beaches, oyster bars and subtidal vegetation. Restoration priorities include serving as a reference site and assessing invasive species control, especially for Phragmites.

Watershed Restoration Action Strategy (WRAS) by the Environmental Protection Agency

The WRAS process is intended to integrate existing state, local and federal programs in a coordinated way with local and regional group activities to speed up response and treatment of impaired waters. North Carolina has used this program to heighten the visibility of watershed issues and to funnel grant funds to watersheds such as the Bogue and Core Sounds that are high priorities for restoration.

Coastal Habitat Protection Plans

A key provision of the 1997 Fisheries Reform Act of North Carolina was to create protection plans for key fisheries habitats such as ocean waters and estuaries. The plans are being prepared through an interagency agreement between the Coastal Resources Commission, Marine Fisheries Commission and the Environmental Management Commission. Once complete, the goal of the plans is long-term enhancement of coastal fisheries associated with each coastal habitat. Plans must be prepared by 2003 for the Chowan River, Coastal Ocean, Southern Estuaries, Tar-Pamlico River, Roanoke River, New and White Oak Rivers, Albemarle Sound, Core and Bogue Sounds, Neuse River, Pamlico River and the Cape Fear River.

Plan Elements

Goals

Goals of North Carolina restoration plans include fish and wildlife habitat protection and restoration, as well as restoration and protection of water quality. Both degraded and non-degraded areas are targeted.

Methods

Implementation methods include marsh plantings, wetlands construction, shellfish bed plantings and acquisition of key areas. Many of the efforts are locally driven with support from state and federal agencies. Other efforts include attempts to simplify or modify the regulatory process primarily for shoreline setbacks, bulkheading, buffers and impervious surfaces. In addition, watershed-based planning for pollution prevention is recommended. Public-private partnerships also are common.

Elements of Success

In North Carolina, common elements of success include shoreline grading and marsh planting, sometimes including the use of stone sills in addition to the plantings; wetland creation; and oyster bed plantings. These efforts have been successful in part because of public/private cooperation and partnerships in project planning and implementation. Public participation and education is key for successful implementation.

Information Needs

Key information needs in North Carolina include continued project monitoring and testing of techniques. The greatest challenge ahead in coastal habitat restoration is grappling with global warming and consequent sea level rise.

South Carolina Subregion

Description

The coastal zone of South Carolina encompasses approximately 8,116 square miles and ranks fourth nationally in its acreage of salt marsh estuaries. There are 187 miles of ocean beaches, with 2,876 miles of shoreline around its estuaries, bays, rivers and creeks.

South Carolina estuaries account for almost one-sixth of all salt marshes on the east coast of the United States. These wetlands are dominated by salt marsh cordgrass *(Spartina alterniflora)*. It is estimated that South Carolina's wetlands include 540,445 acres of total coastal marsh, 344,500 acres of salt marsh, and approximately 4.5 million acres of total freshwater wetlands (NOAA, 1979).

Included among South Carolina's freshwater wetlands are approximately 79 coastal impoundments totaling 70,000 acres of impounded coastal marshes. Unique rice field impoundments, dating back to when rice culture was common, attract waterfowl. These former rice fields have been identified for protection under the *North American Waterfowl Management Plan.* Within the Ashepoo-Combahee-Edisto Basin, these rice fields also have been identified for protection under the Nature Conservancy's Last Great Places Program. This system is the largest of its type in the state, with over 3,300 acres of managed impoundments.

North Inlet/Winyah Bay is unique in that it has one undisturbed estuary (North Inlet) and one influenced by human activity (Winyah Bay). Of the 17 estuaries in the state, Winyah Bay is the most important in terms of freshwater marshes, containing nearly 35 percent of South Carolina's freshwater marshes.

Habitat Issues

Status and Trends

The coastal region of South Carolina has experienced a 40 percent population increase in the past 20 years. The population of urban areas has increased 250 percent within this same period (South Carolina Coastal Conservation League, www.scccl.org/programs/programs.htm). This rise in population, along with increased tourism, has altered habitats and water quality.

Significant trends within the coastal zone of South Carolina include hydrologic modifications and conversion of habitats for human uses. Urban expansion has led to conversion of wetlands in various locations, most notably in the areas around Hilton Head, Charleston, North Charleston and in the vicinity of Myrtle Beach and Columbia. Hydrologic modifications include multiple rice field impoundments covering 70,451 acres of land (NOAA, 1979).

Diversion of the Santee River into the Cooper River occurred in 1941 when the Works Progress Administration completed the Santee-Cooper Hydroelectric Project. This effectively increased the drainage area of the Charleston Harbor Estuary by eleven times the original area. The Cooper River was transformed from a tidal slough to a riverine system, and massive shoaling resulted from the project. To alleviate this problem, the Cooper River Rediversion Project diverted approximately 70 percent of the Santee drainage water back into the Santee River through the canal (South Carolina Department of Health and Environment Control, 2000).

Wetlands are being altered or destroyed due to increasing residential, commercial and industrial development, as well as changing forestry practices. South Carolina has been relatively successful in protecting its tidal wetland resources, and has retained approximately 73 percent of its historic acreage. Although tidal wetlands have been relatively well protected, significant losses have occurred in freshwater nontidal areas. Within South Carolina's estuaries, nearly one-third of the shellfish areas are permanently closed (USES, 2000).

Threats

Key threats for this subregion are listed in Table 1.

Restoration Plans

Ashepoo-Combahee-Edisto (ACE) Basin National Estuarine Research Reserve Program

The ACE Basin National Estuarine Research Reserve was established in 1992 and currently encompasses 140,000 acres of protected estuarine lands and waters. The reserve management plan was approved by NOAA in 1992. Important habitats that may be useful for investigation and as reference sites include forested flood plains; fresh, brackish and saltwater marshes; oyster reefs; bird keys and banks; and maritime forests. Restoration priorities include restoring flow to a salt marsh bisected by a road, restoring native terrestrial plants and shellfish habitat, and controlling invasive species. Current restoration projects include shellfish habitat restoration and prescribed burning.

Charleston Harbor Plan

The Charleston Harbor Plan calls for establishment of: vegetated buffers with a minimum average width of 50 feet for all development bordering tidal creeks and rivers; wetland master planning to protect wetlands smaller than one acre; and wetland land banks that would include isolated wetlands. The plan is to be implemented at the local level. It encourages governments to develop mechanisms to allow collection of funds to acquire areas for public recreation and resource conservation. The plan also examines the utilization of oyster shells for erosion control to benefit shoreline and marsh protection; the capacity for the growth of a complex, three-dimensional intertidal habitat; and propagating shellfish restoration.

North Inlet/Winyah Bay National Estuarine Research Reserve

The North Inlet/Winyah Bay National Estuarine Research Reserve was established in 1992 and currently encompasses 12,327 acres of protected estuarine lands and waters. The reserve management plan was approved by NOAA in 1992. Important habitats that may be useful for investigation, especially as reference sites, include abandoned rice fields and canals, tidal creeks, brackish and saltwater marshes, mud flats, sand bars, intertidal oyster reefs and shallow sounds. Restoration priorities lie mainly in invasive species control, especially crustaceans and *Phragmites.* No restoration projects are currently underway, as the North Inlet system remains in a relatively natural, pristine state. Reserve staff members have participated in oyster reef restoration efforts that have taken place outside reserve boundaries.

Wetland Restoration Project

As part of the recent Coastal Program Improvement Project, NOAA's Office of Coastal Resource Management (OCRM) identified areas for potential restoration along the New, Waccamaw and Ashley Rivers. To accomplish this, OCRM has developed the South Carolina Coastal Stream Corridor Restoration Initiative. The initiative focuses on stormwater

management and channelization, and impacts on riparian habitat. Assistance from NOAA and EPA will help to develop an ongoing program of technical assistance and guidance for local governments in the identification and restoration of impaired stream corridors and associated wetlands.

Oyster Habitat Restoration/Enhancement Plan
This restoration plan will help reduce shoreline erosion, improve water quality, and provide additional refuge, spawning areas and habitat for prey species. The community-based Oyster Habitat Restoration and Enhancement Plan is a cooperative effort between the South Carolina Department of Natural Resources (SCDNR) and local and state partners to involve citizens, schools and community organizations in oyster habitat restoration projects. Funding for this effort came from NOAA's Community-Based Restoration Program, Five Star Challenge Grant, the Hilton Head Island Foundation, and South Carolina Sea Grant. Partners include Charleston Math and Science Hub, South Carolina Aquarium, South Carolina Coastal Conservation League, SCDNR, Sea Grant, and the University of South Carolina. Components include building oyster habitats, shell recycling, educational activities and related research.

The Wetlands Reserve Program
The Wetlands Reserve Program is a voluntary program to restore and protect wetlands on private property. It is an opportunity for landowners to receive financial incentives to enhance wetlands in exchange for retiring marginal agricultural land.

Santee-Cooper Basin Diadromous Fish Passage Restoration Plan
This management plan provides a framework for rebuilding populations of the basin's diadromous fish. Some of the target species include American shad, hickory shad, Atlantic sturgeon, shortnose sturgeon and striped bass. These species historically ascended the Santee River and its tributaries to locations above the fall line. Some species even traveled into North Carolina. In the eastern U.S., the Santee-Cooper Basin is second only to the Susquehanna River Basin in terms of drainage area and volume of flow. The basin's diadromous fish stocks are significantly depressed relative to historic levels. This plan seeks to restore diadromous fish populations by eliminating or reducing migration blockages and habitat alterations caused by dams. The USFWS, NOAA's National Marine Fisheries Service, and the SCDNR have developed this plan. To implement the plan, development of partnerships is envisioned. Prospective partners include state and federal resources agencies, the U.S. Army Corps of Engineers, Santee-Cooper Public Service Authority, South Carolina Electric and Gas Company, Duke Power Company, local governments, the private sector, and others who manage, use, or enjoy the publicly-owned water resources of the Santee-Cooper Basin.

Plan Elements

Goals
Goals of South Carolina restoration plans include stormwater management, erosion reduction, natural vegetated buffer maintenance and oyster bed habitat restoration for the protection of the ecological and consumptive values of the resource. In addition, South Carolina is conducting research to use as a scientific basis for habitat restoration.

Methods
Implementation methods for restoration in South Carolina include oyster bed plantings, acquisition of stream banks, wetland creation and financial incentives for private wetlands protection.

Elements of Success
Oyster reef plantings and restoration of mosquito impoundments have been successful in South Carolina. Partnerships are key to the success of these projects.

Information Needs
In South Carolina, there is a need to study the impact of the restoration of impoundments on seagrasses due to changes in hydrology. Oyster reefs are treated as a fishery resource rather than a habitat. Mudflats and beaches are often neglected in restoration planning despite the important ecosystem functions they serve.

GEORGIA SUBREGION

Description
Georgia is comprised of five estuaries: the Savannah, Ogeechee, Altamaha, Satilla and St. Marys Rivers. The Altamaha is the largest river of the Georgia coast and the second largest basin in the eastern United States (Georgia Rivers LMER, http://wiegert.marsci.uga.edu). It is a relatively undisturbed analogue of the Savannah River, with no major channelization, dredging or reservoirs.

The Georgia coastline is approximately 100 miles long. The coastline consists of a chain of barrier islands separated from the mainland by a four- to six-mile wide band of coastal marsh.

Habitat Issues

Status and Trends

The Georgia coastline is relatively unaffected by the heavy development that has been seen in other areas of the south Atlantic coast in recent years, and Georgia's barrier islands and marshes have been less altered by human activity than in most other coastal areas. Development has largely been of a residential or recreational nature and has usually had a minimal effect on salt marshes. In earlier days, considerable alteration of many marshes near the barrier island uplands was due to cultivation of sea-island cotton. Even though U.S. Highway 17 was paved through coastal Georgia in 1926, only four barrier islands have road access from the mainland. Seven of the 14 barrier islands are in federal ownership, and thus protected from heavy development and loss of habitat areas.

Threats

Key threats for this subregion are listed in Table 1.

Restoration Plans

Sapelo Island National Estuarine Research Reserve Management Plan

The Sapelo National Estuarine Research Reserve was established in 1976 and currently encompasses 6,111 acres of protected estuarine lands and waters. The reserve management plan was approved by NOAA in 1999. Important habitats that may be useful for investigation and as reference sites include maritime forests, freshwater ponds, sloughs, salt marshes, and barrier island beaches and dunes. Restoration priorities include maritime forest and ephemeral wetlands restoration, rare endemic habitat restoration (e.g., longleaf pine, pond pine habitats); hydrologic, terrestrial and associated freshwater habitat; wetland reclamation by restoration of natural hydrology; dune stabilization and restoration; invasive plant control and invasive species control (e.g., popcorn trees, feral hogs). Current restoration projects include rare and endemic habitat restoration, selective timber harvest, maritime forest restoration and prescribed burning. Comprehensive mapping and monitoring of oyster reef habitat and biology, and high marsh plant community interaction have been conducted to identify restoration needs in these areas.

Basinwide Plans

To date, draft basin-wide plans for coastal river basins do not specifically address coastal habitat restoration except to mention the Department of Natural Resources and Wildlife Resources Division's land acquisition program that began in 1987 to acquire 60,000 acres of additional land for Wildlife Management Areas and Public Fishing Areas. This initiative was funded by $30 million of 20-year obligation bonds to be paid off by hunting and fishing license increases and Wildlife Management Area permit fees.

Preservation 2000 and River Care 2000 Programs

The Land, Water, Wildlife and Recreation Heritage Fund will derive funding from an increase in the real estate transfer tax to $2 per $1000, generating more than $30 million each year. 1998 legislation authorizes the fund to be used to purchase land to protect and preserve natural wildlife habitat, river corridors and wetlands along major rivers.

Altamaha Buffers

The state of Georgia, along with International Paper and Georgia-Pacific, will protect nearly 300 feet of buffers along the Altamaha River at a cost of $1.4 million in state funds. The state purchased timber rights from the companies. In addition, the paper companies will fund The Nature Conservancy of Georgia over a five-year period to direct research projects on the river.

Georgia Wetlands Trust Fund (GWTF)

Created in 1997 in an agreement between the U.S. Army Corps of Engineers and the Georgia Land Trust Service Center, the GWTF provides alternatives to wetland mitigation requirements by allowing an alternative to provide money to the GWTF to purchase wetlands. The GWTF currently focuses on preservation with some limited restoration.

Plan Elements

Goals

Goals of Georgia restoration plans primarily include reinstatement of natural processes that have been significantly disrupted. There are very limited restoration goals for the Georgia coast.

Methods

Current methods primarily include the use of existing regulatory programs. In addition, acquisition programs as a form of habitat protection are being adopted and implemented.

Elements of Success

In Georgia, shorelines are primarily managed by the Coastal Marshlands Protection Act. Conservation easements are a successful technique for ecosystem protection but for the most part there is very little restoration occurring in Georgia.

Information Needs

Of the plans reviewed for this subregion, no information needs were identified.

Florida Subregion

Description

This coastal subregion includes peninsular Florida extending from the northern edge of Lake Okeechobee north to the transitional zone around the Suwanee River in northern Florida, and from the northern edge of Lake Okeechobee south through the Florida Keys, including the Everglades and Florida Bay. The region has very little topographic relief, but slight changes in elevation have important consequences for vegetation and the diversity of habitat types. The South Florida and Florida Keys region contains one of North America's most diverse assemblages of terrestrial, estuarine and marine fauna and flora and represents one of the most complex ecosystems on earth.

Within Florida, the Indian River Lagoon (IRL) is located in the zone where tropical and temperate climates meet. Flora and fauna include tropical and subtropical species that cannot survive in colder climates in addition to species that thrive in cooler weather. This has resulted in more species and a wider range of species than in any other American estuary. The IRL covers 40 percent of the east coast of Florida. Since 1916, human activities have resulted in the enlargement of the lagoon's watershed from 572,000 acres to more than 1.4 million acres—an increase of 146 percent. The IRL is located along the Atlantic Flyway, a route used by millions of birds that migrate between eastern North America, South America and the Caribbean.

The South Florida and Florida Keys region includes mangrove-fringed shorelines, mangrove islands, sea grass meadows, hard bottom habitats, thousands of patch reefs, and one of the world's largest coral reef tracts. The Keys are made up of over 1,700 islands encompassing approximately 103 square miles. They have a shoreline length of 1,857 miles and are permanently inhabited from Soldier Key to Key West.

The largest seagrass bed yet documented (5,792 square miles) occurs off the south Florida coast (www.fiu.edu/~seagrass/). Seagrasses in Florida Bay have been adversely impacted by a decrease in freshwater inflow due to upstream hydrological alterations resulting in a massive seagrass die-off in 1987. The Comprehensive Everglades Restoration Plan proposes in part to restore freshwater inflow from the Everglades into Florida Bay.

Habitat Issues

Status and Trends

Rapid urbanization and associated coastal development in southeastern Florida over the last 100 years have virtually eliminated the low coastal wetlands along approximately 21 miles of mainland shoreline and approximately 12 miles of barrier island shoreline bordering Biscayne Bay. These estuarine ecosystems have been replaced by eroding, altered shorelines or hardened shorelines with numerous bulkheads (Milano, 1999).

In southeastern Florida, development of reclaimed swamp lands, uplands and newly created lands produced by dredging and filling practices essentially began with the completion of the Florida East Coast Railroad in 1896. This, and networks of draining, caused serious environmental degradation to southeastern Florida's coastal wetlands and estuaries.

Dredging and filling in the early 1900s to create navigation channels and harbors in Biscayne Bay resulted in over 20 human-made spoil islands and two partially filled natural mangrove islands. Dredging, draining and diking of the river systems leading into and out of Lake Okeechobee occurred in the 1950s with the implementation of the Central and Southern Florida (CS&F) Project under the Flood Control Act of 1948. The first phase of the CS&F Project was undertaken for flood control, water level control, water conservation, prevention of salt water intrusion, and preservation of fish and wildlife (www.evergladesplan.org/the_plan/csf_devel.htm). Over the years, the waters of the Everglades also have been drained and diverted to create agricultural and residential lands, which has inevitably altered the natural hydrologic flow. The Comprehensive Everglades Restoration Plan (CERP) seeks to mitigate changes to South Florida ecosystems by restoring freshwater flow to the Everglades and Florida Bay, though the plan does not attempt to restore the hydrologic flow to what it once was 100 years ago (www.evergladesplan.org).

During the summer of 1987, a massive seagrass die-off began in the Florida Bay that resulted in 15 square miles of seagrass loss. This was just the beginning of a series of major ecological events that culminated in grave concern that the bay's ecosystem was near an unprecedented collapse (Fourqurean and Robblee, 1999). These events include plankton blooms and sponge die-offs in the 1990s as well as mangrove die-backs and reduced catches in some fisheries (www.aoml.noaa.gov/flbay/). As a result, South Florida received national attention and the CERP was authorized under Section 601 of the Water

Resources Development Act of 2000 to restore the quantity, quality, timing and distribution of freshwater flows into Florida Bay with downstream effects on the Florida Keys National Marine Sanctuary (www.evergladesplan.org).

Threats

Key threats for this subregion are listed in Table 1.

Restoration Plans

Florida Keys National Marine Sanctuary Plan

Within this plan, the designation of special-use areas includes "restoration areas" to provide for restoration of degraded or otherwise injured sanctuary resources. No person may enter, disturb or interfere with "such areas designated as a recovery area or a restoration area," or engage in "habitat manipulation related to restoration of degraded or otherwise injured sanctuary resources, or activities reasonably necessary to monitor recovery of degraded or otherwise injured sanctuary resources."

The Surface Water Improvement Management (SWIM) Program

The SWIM Program was created by the Florida Legislature in the late 1980s to address concerns over nonpoint sources of pollution. SWIM addresses the needs of a waterbody as a system of connected resources, rather than as isolated wetlands or water bodies. While the state's five water management districts and the Department of Environmental Protection are directly responsible for the SWIM program, they work in concert with federal, state and local governments and the private sector.

SWIM develops carefully crafted plans for at-risk water bodies, and directs the work needed to restore damaged ecosystems, prevent pollution from runoff and other sources, and educate the public. SWIM plans are used by other state programs, such as Save Our Rivers, to help make land-buying decisions, and by local governments to help make land-use management decisions. Today, 29 water bodies are on the SWIM waterbody priority list.

Indian River Lagoon Comprehensive Conservation and Management Plan

The Indian River Lagoon CCMP was developed after the 1994 Indian River Lagoon SWIM Plan. The strategies for restoration and maintenance contained within the Indian River Lagoon SWIM Plan may be viewed as the technical backbone of the Indian River Lagoon CCMP or as the phased program approach used to identify and define priority problems, establish causes and devise alternate strategies to address those problems. Five program objectives were developed. One address habitat preservation and restoration. Within these objectives, specific goals and action plans are identified. Examples of restoration action plans are listed below.

- *Seagrass Action Plan:* Implement a program of restoration and management activities to maintain, protect and restore the seagrass and submerged aquatic vegetation community of Indian River Lagoon.

- *Wetlands Restoration and Preservation Plan:* Improve implementation of wetlands protection programs, undertake a regular review of wetlands protection rules and regulations, establish wetlands or shoreline setbacks or buffers; acquire ownership or control of wetlands, reconnect impounded wetlands to the Indian River Lagoon, restore wetlands and shorelines, and remove trash and litter from wetlands and shorelines.

- *Restoration and Management Action Plan:* Identify shorelines or wetlands which are either barren of vegetation or have been invaded by exotic plant species, classify and rank these areas based on the need for restoration and the probable success of restoration projects. Develop partnerships or coalitions with local governments, interest groups, the private sector or other parties to accomplish restoration projects.

- *Impounded Marsh Restoration and Management Plan:* Complete or continue the diagnostic, management or feasibility projects related to marshes impounded for mosquito control found in the 1994 SWIM Plan and continue acquisition of privately owned impounded marshes or obtain conservation easements allowing restoration of their natural function. Plans are being developed for land acquisition, and public and governmental support and involvement.

Biscayne Bay SWIM Plan

Substantial restoration efforts have been undertaken in Biscayne Bay by Dade County and local municipalities. South Florida Water Management District and SWIM funds have been used to support projects to restore mangroves at Oleta River State Recreation Area, restore freshwater wetlands at the Bulk Carrier Site and redistribute flow adjacent to the L-31E Canal. The need for restoration is based on the assumption that some areas have been significantly degraded by pollution, structural change and other human activities. Restoration activities are designed to reduce the influx of excessive amounts of nutrients and other pollutants, and to make structural changes as needed to restore appropriate biotic communities, substrate, hydroponic, or physical conditions that will accelerate recov-

ery of the system. Bayside restoration is targeted toward three major issues: water quality, freshwater inputs, and habitat and living resources. Restoration efforts are limited to areas and methods where success is most likely. Planting mangroves in properly prepared and stabilized substrate, and planting marsh vegetation, have proven effective when planting and maintenance are properly designed and supervised.

Biscayne Bay Island Restoration and Enhancement Projects

Components of these projects include stabilizing shorelines, removing exotic trees and fill, establishing flushing channels, and planting mangroves and native salt/drought-tolerant uplands vegetation. Over the past 10 years, the Department of Environmental Resources Management has coordinated 14 island projects through the cooperative efforts of federal, state and local agencies. Cost-effective techniques were developed and used in implementing these successful projects. Island restoration and enhancement activities are underway to stabilize eroding shorelines, restore historical dune communities and wetlands, eradicate exotic vegetation, and create wetlands, dune, coastal strand and tropical hardwood hammock communities. Island stabilization and enhancement have been funded primarily through the Florida Inland Navigation District Waterways Assistance Program and the Biscayne Bay Environmental Enhancement Trust Fund.

Guana Tolomato Matanzas National Estuarine Research Reserve

The Guana Tolomato Matanzas National Estuarine Research Reserve was established in 1999 and currently encompasses 76,000 acres of protected coastal lands and waters. The reserve management plan was approved by NOAA in 1998. Important habitats that may be useful for investigation and as reference sites include estuarine lagoons, oyster bars, tidal creeks, wetlands, maritime hammock, pine flatwoods, coastal scrub, sand dunes and beaches. Restoration priorities include treatment of surface runoff, establishment of buffers to urban development, and restoring and stabilizing natural shorelines. Current restoration projects are primarily mitigation activities and the conversion of former planted pine plantations to more natural forest and wetland communities.

Remarkable Coastal Places Program

This program was initiated by the Florida Coastal Management Program to better address endangered coastal habitats and other historical and cultural values by providing funding to local governments for projects. This is part of their Coastal Partnership Initiative and could be an avenue for local and state partnerships in restoration.

Optimizing Indian River Lagoon Wetland Habitat Restoration and Management

The goals of this project are to determine if reestablishment of the hydroponic connection between impounded marshes and the Indian River Lagoon (IRL) can restore the ecological function of the impoundments to a state similar to that of “native” marshes, and to determine how continued hydroponic management would affect the restoration process. Many local state and federal agencies, including the U.S. Fish and Wildlife Service, recommended restoration of the hydroponic connection between the marshes and the lagoon. Approximately 28,000 (80 percent) of the 35,000 acres of the IRL's impounded estuarine wetlands are located within the Merritt Island National Wildlife Refuge (MINWR) and are a part of the Kennedy Space Center. The initiative fills needs for a broad range of programs and organizations. This work is directly called for by the IRL National Estuary Program's Comprehensive Conservation and Management Plan to optimize management of IRL wetlands. It supports the objectives of the IRL SWIM Plan. MINWR will manage a selected group of impoundments under various management strategies agreed upon by the participating researchers. At the end of data collection, and when data analysis and results synthesis are complete, a review of wetland restoration techniques and wetland management practices will be conducted. Results of the review will be a series of recommendations for restoration, preservation and management of estuarine wetlands.

South Florida Initiative

Support for habitat restoration also is available through the South Florida Initiative. The South Florida ecosystem is the principal nursery area for the largest commercial and sport fisheries in Florida. It also is the home of the largest wilderness east of the Mississippi River, the location of the only living coral reef adjacent to the United States, the most significant breeding ground for wading birds in North America, the main producer of the nation's winter vegetables, home to two Native American nations, and a major tourist region. Fifty percent of the region's wetlands have been lost to suburban and agricultural development. Altered hydrology and water management throughout the system has had a major impact on the area. To address the issues surrounding the South Florida ecosystem, the U.S. EPA is working in partnership with several local, regional, state and federal agencies. The goal is to assure the long-term sustainability of the region's varied natural resources while providing for the coexistence of extensive agricultural operations and a continually expanding human population. Many simultaneous restoration strategies are underway. A federal task force on South Florida ecosystem restoration was formed in 1993 to integrate, focus and direct ecosystem pro-

tection and restoration efforts. Several ecosystem restoration strategies are underway that, if implemented, would cost over $2 billion. The U.S. Army Corps of Engineers has proposed several structural or operation changes for the Central and Southern Florida (C&SF) Flood Control Project in order to improve hydrologic conditions within the Everglades and Florida Bay. They also are proceeding with a comprehensive review of the C&SF project in an effort to further ecosystem restoration while meeting the projected needs of urban areas and agriculture for the year 2050. Implementation of the selected alternative, the Comprehensive Everglades Restoration Plan, is projected to cost over $8 billion. Phosphorus control programs consisting of agricultural best management practices and constructed wetlands managed for phosphorus removal are underway to reduce phosphorus loading into the oligotrophic Everglades wetlands. The South Florida Initiative also directs agencies to promote opportunities to link restoration plans and projects into federal programs and initiatives that focus on improving water quality.

Comprehensive Everglades Restoration Plan (CERP)
This plan is designed to be a collaborative effort among governmental and nongovernmental entities and provides a 50 percent federal share for projects carried out under the CERP. The overarching objective of the CERP is the "restoration, preservation, and protection of the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection." The governing board of the South Florida Water Management District has approved eight contracts totaling more than $68 million for the Everglades Construction Project, an effort designed to improve the quality of water reaching the huge ecosystem (www.evergladesplan.org).

Plan Elements

Goals
Goals of Florida's restoration plans include restoration of habitats that have been converted to mosquito impoundments as well as restoration of seagrasses, mangroves and coral reefs. The plans focus both on habitat and water quality issues with the goal of restoring the natural functions of the ecosystem and reducing nonpoint source pollution (e.g., the SWIM Program). In addition, plans call for stabilization of eroding shorelines and the eradication of exotic species.

Methods
Implementation of the restoration plans calls for designation of special-use areas to provide for restoration. In addition, specific plans for planting seagrasses, mangroves and corals are in place. Florida incorporates restoration programs into some of their regulatory efforts including those for buffers and setbacks. Partnerships among federal, state and local governments and the academic community are common. Use of volunteers for plantings heightens public awareness of issues.

Elements of Success
Elements of success include: stabilizing unconsolidated shorelines with limestone boulders; creating intertidal planters where wetland vegetation can become established while protected from wave action; filling deep, barren bottom areas to raise them to points where light levels can support healthy productive bottom communities; planting of wetland vegetation in appropriate areas; enforcing reduced speed limits for vessels; controlling exotic plants; restoring sheet flow, tidal flushing or water levels in wetlands impacted by fill or excessive drainage; and conducting long-term evaluation.

Coastal marsh restoration and creation efforts have been more successful than similar inland attempts. This success appears to be due largely to researchers' abilities to more accurately predict hydrologic patterns in tidally influenced areas than in freshwater settings. Also, coastal restoration efforts have perhaps had a longer history than freshwater wetland restoration. In the Indian River Lagoon, publicly owned impoundments are under rotational impoundment management to restore connection between impoundments and the lagoon. Restoration is less experimental today, although site preparation and substrate stabilization are critical, and planting and maintenance must be properly designed and closely supervised.

Information Needs
In Florida, continued monitoring of projects is integral to the success of restoration efforts. Coral and seagrass habitats tend to be more difficult to establish in the long-term; more research that focuses on identifying viable restoration techniques for these habitat types is necessary. Adequate training can increase the likelihood of successfully restoring these habitats. Also identified was a need to increase public and government involvement in activities designed to protect and restore the coastal environment.

Puerto Rico and U.S. Virgin Islands Subregion

Description
During the ice ages, Puerto Rico and most of the Virgin Islands, including St. John, St. Thomas and the British Virgin Islands, were a single land mass called the Puerto Rican Bank.

The thousands of islands and cays composing the Greater and Lesser Antilles are among the most biologically interesting areas of the world. Centrally located in the West Indies, Puerto Rico and the Virgin Islands are in the eastern extreme of the Greater Antilles, about halfway between the southern tip of Florida to the north and the Caribbean coast of Venezuela. Puerto Rico is roughly 111 miles long by 36 miles wide. Aside from the main U.S. Virgin Islands, 54 small islands flank St. Thomas, St. Croix and St. John.

Puerto Rico and the U.S. Virgin Islands share the following physical and biological coastal features: a limited coastline extension, a restricted shelf dimension, a permanent temperature gradient, oligotrophic waters and sparse upwelling zones.

The U.S. Virgin Islands and Puerto Rico provide critical nesting, foraging and developmental habitat for three species of sea turtle: the leatherback and the hawksbill, (both endangered species) and the green sea turtle (listed as endangered/threatened). Coral reefs and seagrasses serve as habitat for these species, where they typically remain until they reach maturity. Green and hawksbill sea turtles forage throughout the coastal areas, but the only island which still supports any green sea turtle nesting is St. Croix, with an average of 100 nests each year between 1980 and 1990 (Eckert, 1992).

At present there are 22,138 acres of mangrove forests in Puerto Rico. Mangroves have actually increased due to protection of the resource over the last 20 years. In contrast, marsh areas in 1995 equaled 1,959 acres, a decrease of 42.2 percent since 1936.

Tropical Atlantic seagrass beds in the Caribbean are highly productive systems. They are the most important grazing areas for the green sea turtle and the West Indian manatee. Seagrass beds also are one of the most common coastal zones in Puerto Rico (Pabon and Carrubba, personal communication). They are most extensive on the southeast side of the island, but also can be found off the northwest coast.

Puerto Rico has about 60 estuaries including small drainages (Pabon and Carrubba, personal communication). About half of these are larger systems with drainages that have headwaters in the central mountain ranges and drain to the coast. Note that the classical definition of “estuary” does not apply in the Caribbean islands, where the coastal zone is confined due to the geography and alternately wet-dry climate of the islands.

Puerto Rico also has a number of fresh and saltwater wetlands, coastal barriers, and coastal lagoons, in addition to varying reef structures. Similarly, the U.S. Virgin Islands also have fresh and saltwater wetlands and varying reef structures.

Habitat Issues

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Status and Trends

Increases in tourism and associated real estate development have greatly impacted the key habitats and species of this region. Due to relatively long periods of evolutionary isolation, island ecosystems are more susceptible to change than those on continents. Deforestation and fire, introduction of grazing animals, cultivation and the introduction of weedy plants have all contributed to alteration of the ecosystem. General recognition of the importance of the natural environment by local citizens may help reverse this trend.

Threats

Key threats for this subregion are listed in Table 1.

Restoration Plans

Puerto Rico San Juan Bay Estuary Comprehensive Conservation Management Plan

Goals of the plan include planting mangroves and native trees; increasing acreage in the nature reserve; increasing buffer zones; waste management and recycling of marine debris; improving water quality; increasing and protecting existing habitat; encouraging community involvement; restoring seagrasses; and protecting habitat. Demonstration projects include native tree planting to create buffer zones—especially mangroves—which were severely impacted by Hurricane Georges in 1998.

Saltwater Wetlands Conservation and Management Plan for St. Croix

The Division of Fish and Wildlife of the Department of Planning and Natural Resources formulated a strategy to achieve

"no net loss" of saltwater wetlands on St. Croix and long-term gain through restoration of degraded wetlands. Restoration projects focus on enhancing wetlands as habitat for fish and wildlife and increasing educational and recreational opportunities for the U.S. Virgin Islands' community. A collaborative planning effort will be developed that includes all stakeholders and interested parties. An important part of the process is to develop a set of blanket regulations and permit conditions for any proposed development in adjacent wetlands.

Jobos Bay National Estuarine Research Reserve Management Plan

The Jobos Bay National Estuarine Research Reserve was established in 1981 and currently encompasses 2,883 acres of protected estuarine lands and waters. The reserve management plan was approved by NOAA in 2001. Important habitats that may be useful for investigation and as reference sites include subtropical dry forests, mangroves, salt and mud flats, seagrass beds and coral reefs. Restoration priorities include shoreline erosion on offshore cays, hydrological restoration, and mangrove and coral reef restoration. Current restoration projects include dike removal, channel filling, and studies of soil condition, water quality and mangrove productivity for hydrological restoration and mangrove restoration.

Plan Elements

Goals

Goals of Puerto Rico's restoration plans include habitat protection and restoration, especially for mangroves and coral reefs. They also include "no net loss" of wetlands, watershed restoration, mangrove and coral reef habitat restoration and shoreline erosion control. Plans have also established a goal of shoreline debris removal.

Methods

Implementation of restoration plans primarily involves the planting of mangroves or restoration of coral reef habitats. The Riley Encased Methodology is used to support the base of mangrove plantings to improve their chance of success along high-energy shorelines. Plantings are surrounded by PVC pipe as they grow. Volunteers are key to the success of restoration programs and aid in educating the general public about the importance of protecting natural resources.

Elements of Success

Mangrove plantings often are successful in the Caribbean. Use of the Riley Encased Method (REM) helps protect mangrove seedlings from wave action, tides, upland runoff and debris. There has been an 87 percent survival rate with the use of REM. In addition, the use of volunteers fosters a better understanding and appreciation for the resource. Partnerships between federal and state agencies, universities and citizens are important to the success of restoration projects. In addition, acquisition efforts, primarily in national parks, are critical to habitat restoration and protection (The Nature Conservancy also acquires lands and has a reserve in the U.S. Virgin Islands).

Information Needs

More research is needed on planting methodologies for mangroves. In addition, the success of transplanting and restoring corals requires additional research. Monitoring increases the chance of restoration success and can lead to more effective restoration methods. An effective method used in the emergency restoration of corals off Mona Island, Puerto Rico, was reattaching and stabilizing broken pieces of coral using stainless steel wire and nails. Newly planted mangrove seedlings and restored corals (as well as adult mangroves and corals) can be vulnerable to natural factors.

Successful coral reef, mangrove and seagrass restoration requires adaptive management that responds quickly to changing environmental conditions. This depends on baseline assessments and monitoring programs, as well as thorough, long-term evaluation of completed restoration actions that track coral reef ecosystem health and recovery, and reveal significant trends in their condition before irreparable harm occurs. Assessment and monitoring also play a vital role in guiding and supporting the establishment of management strategies. Information needs include fish and benthic habitat assessments and monitoring in the Florida Keys, the U.S. Virgin Islands and Puerto Rico and better planning and additional resources dedicated to comprehensive evaluation of completed restoration actions to better guide and develop future restoration efforts. There also is a need to conduct locally focused socio-economic studies of high-risk anthropogenic threats in specific southeast coral reef habitats in order to resolve important user conflicts affecting these and other reef areas (Bruckner, personal communication).

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